

COMPOSITIONS COMPRISING A CYCLOHEXANEDIONE  
HERBICIDE AND AN ADJUVANT

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The present invention relates to a herbicidal composition, to its preparation and use. In particular it relates to a herbicidal composition which demonstrate improved activity over the prior art compositions.

5       The protection of crops from weeds and other vegetation that inhibits crop growth is a constantly recurring problem in agriculture. To help combat this problem, researchers in the field of synthetic chemistry have produced an extensive variety of chemicals and chemical formulations effective in the control of such unwanted growth. Chemical herbicides of many types have been disclosed in the literature and a large number are in  
10       commercial use. Commercial herbicides and some that are still in development are described in The Pesticide Manual, 12th edition, published in 2000 by the British Crop Protection Council.

Many herbicides also damage crop plants. The control of weeds in a growing crop therefore requires the use of so-called 'selective' herbicides which are chosen to kill the  
15       weeds while leaving the crop undamaged. Few selective herbicides are selective enough to kill all the weeds and leave the crop completely untouched. In practice, the use of most selective herbicides is actually a balance between applying enough herbicide to acceptably control most of the weeds whilst causing only minimal crop damage.

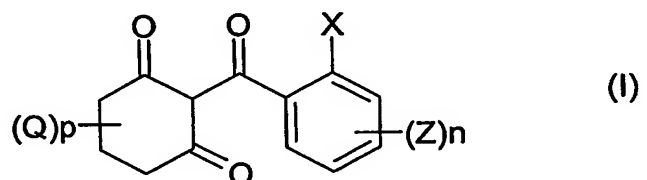
One important class of selective herbicides are 2-(substituted benzoyl)-1,3-  
20       cyclohexanedione compounds disclosed, *inter alia*, in United States Patent Nos. 4,780,127, 4,938,796, 5,006,158 and 5,089,046 the disclosures of which are incorporated herein by reference. A particularly preferred 2-(substituted benzoyl)-1,3-cyclohexanedione is mesotrione, chemical name 2-(2-nitro-4-methylsulfonylbenzoyl)-cyclohexanedione. This is known largely for use to selectively control weeds in a corn  
25       (maize) crop, both before the crop emerges from the ground (pre-emergent) and after (post-emergent).

EP0579052 discloses a plant treatment agent comprising at least one biocide and an accelerator which may be *inter alia* a phosphate. US 2 927 014 discloses the use of a range of organic phosphonate and phosphinate compounds as herbicides. WO93/04585  
30       discloses a herbicidal composition comprising at least one phosphonate or phosphinate and at least one compound selected from phenmedipham, desmedipham, metamitron,

lenacil, ethofumesate and chloridazon. WO94/18837 teaches the use of a specific phosphonate, bis (2-ethylhexyl) 2-ethylhexyl phosphonate, as adjuvant to improve the bioperformance of specified herbicides. However, the particular use of phosphonate and phosphinate in improving the efficacy of 2-(substituted benzoyl)-1,3-cyclohexanedione compounds is wholly unexpected.

Accordingly, the present invention provides a herbicidal composition comprising:

- i) a 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I)



wherein X represents a halogen atom; a straight- or branched-chain alkyl or alkoxy group containing up to six carbon atoms which is optionally substituted by one or more groups  $-OR^1$  or one or more halogen atoms; or a group selected from nitro, cyano,  $-CO_2R^2$ ,  $-S(O)_mR^1$ ,  $-O(CH_2)_rOR^1$ ,  $-COR^2$ ,  $-NR^2R^3$ ,  $-SO_2NR^2R^3$ ,  $-CONR^2R^3$ ,  $-CSNR^2R^3$  and  $-OSO_2R^4$ ;

$R^1$  represents a straight- or branched-chain alkyl group containing up to six carbon atoms which is optionally substituted by one or more halogen atoms;

$R^2$  and  $R^3$  each independently represents a hydrogen atom; or a straight- or branched-chain alkyl group containing up to six carbon atoms which is optionally substituted by one or more halogen atoms;

$R^4$  represents a straight- or branched-chain alkyl, alkenyl or alkynyl group containing up to six carbon atoms optionally substituted by one or more halogen atoms; or a cycloalkyl group containing from three to six carbon atoms;

each Z independently represents halo, nitro, cyano,  $S(O)_mR^5$ ,  $OS(O)_mR^5$ ,  $(C_1-C_6)$ -alkyl,  $(C_1-C_6)$ alkoxy,  $(C_1-C_6)$ haloalkyl,  $(C_1-C_6)$ haloalkoxy, carboxy,  $(C_1-C_6)$ -alkylcarbonyloxy,  $(C_1-C_6)$ alkoxycarbonyl,  $(C_1-C_6)$ alkylcarbonyl, amino,  $(C_1-C_6)$ -alkylamino,  $(C_1-C_6)$ dialkylamino having independently the stated number of carbon atoms in each alkyl group,  $(C_1-C_6)$ alkylcarbonylamino,  $(C_1-C_6)$ alkoxycarbonylamino,  $(C_1-C_6)$ alkylaminocarbonylamino,  $(C_1-C_6)$ dialkylaminocarbonylamino having independently the stated number of carbon atoms in each alkyl group,  $(C_1-$

C<sub>6</sub>)alkoxycarbonyloxy, (C<sub>1</sub>-C<sub>6</sub>)alkylaminocarbonyloxy, (C<sub>1</sub>-C<sub>6</sub>)dialkylcarbonyloxy, phenylcarbonyl, substituted phenylcarbonyl, phenylcarbonyloxy, substituted phenylcarbonyloxy, phenylcarbonylamino, substituted phenylcarbonylamino, phenoxy or substituted phenoxy;

5 R<sup>5</sup> represents cyano, -COR<sup>6</sup>, -CO<sub>2</sub>R<sup>6</sup> or -S(O)<sub>m</sub>R<sup>7</sup>;

R<sup>6</sup> represents hydrogen or straight- or branched-chain alkyl group containing up to six carbon atoms;

10 R<sup>7</sup> represents (C<sub>1</sub>-C<sub>6</sub>)alkyl, (C<sub>1</sub>-C<sub>6</sub>)haloalkyl, (C<sub>1</sub>-C<sub>6</sub>)cyanoalkyl, (C<sub>3</sub>-C<sub>8</sub>)cycloalkyl optionally substituted with halogen, cyano or (C<sub>1</sub>-C<sub>4</sub>)alkyl; or phenyl optionally substituted with one to three of the same or different halogen, nitro, cyano, (C<sub>1</sub>-C<sub>4</sub>)haloalkyl, (C<sub>1</sub>-C<sub>4</sub>)alkyl, (C<sub>1</sub>-C<sub>4</sub>)alkoxy or -S(O)<sub>m</sub>R<sup>8</sup>;

R<sup>8</sup> represents (C<sub>1</sub>-C<sub>4</sub>)alkyl;

each Q independently represents (C<sub>1</sub>-C<sub>4</sub>)alkyl or -CO<sub>2</sub>R<sup>9</sup> wherein R<sup>9</sup> is (C<sub>1</sub>-C<sub>4</sub>)alkyl;

15 m is zero, one or two;

n is zero or an integer from one to four;

r is one, two or three; and

p is zero or an integer from one to six; and

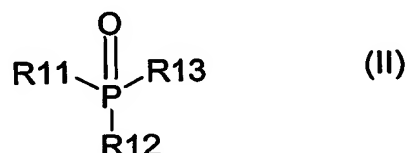
20 ii) an organic phosphate, phosphonate or phosphinate adjuvant at a concentration of less than 0.5% v/v when added to a spray tank as a tank mix additive or when co-formulated with a herbicide to produce a spray tank concentration of less than 0.5% v/v.

25 Suitably, X is chloro, bromo, nitro, cyano, C<sub>1</sub>-C<sub>4</sub> alkyl, -CF<sub>3</sub>, -S(O)<sub>m</sub>R<sup>1</sup>, or -OR<sup>1</sup>; each Z is independently chloro, bromo, nitro, cyano, C<sub>1</sub>-C<sub>4</sub> alkyl, -CF<sub>3</sub>, -OR<sup>1</sup>, -OS(O)<sub>m</sub>R<sup>5</sup> or -S(O)<sub>m</sub>R<sup>5</sup>; n is one or two; and p is zero.

30 Preferably, the 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I) is selected from the group consisting of 2-(2'-nitro-4'-methylsulphonylbenzoyl)-1,3-cyclohexanedione, 2-(2'-nitro-4'-methylsulphonyloxybenzoyl)-1,3-cyclohexanedione, 2-(2'-chloro-4'-methylsulphonylbenzoyl)-1,3-cyclohexanedione, 4,4-dimethyl-2-(4-methanesulphonyl-2-nitrobenzoyl)-1,3-cyclohexanedione, 2-(2-chloro-3-ethoxy-4-

methanesulphonylbenzoyl)-5-methyl-1,3-cyclohexanedione and 2-(2-chloro-3-ethoxy-4-ethanesulphonylbenzoyl)-5-methyl-1,3-cyclohexanedione.

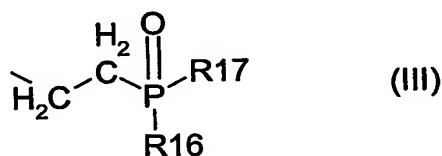
Suitably, the phosphate, phosphonate or phosphinate adjuvant is a compound of formula II



5

wherein  $\text{R}^{11}$  is an alkoxy group containing from 4 to 20 carbon atoms or a group  $-\text{[OCH}_2\text{CHR}^{14}]_t\text{-OR}^{15}$  wherein  $\text{R}^{14}$  is hydrogen, methyl or ethyl,  $t$  is from 0 to 50 and  $\text{R}^{15}$  is hydrogen or an alkyl group containing from 1 to 20 carbon atoms; and  $\text{R}^{12}$  and  $\text{R}^{13}$  are independently (i) an alkyl or alkenyl group containing from 4 to 20 carbon atoms; (ii) optionally substituted phenyl; (iii) an alkoxy group containing from 4 to 20 carbon atoms or (iv) a group  $-\text{[OCH}_2\text{CHR}^{14}]_t\text{-OR}^{15}$  as herein defined; or (v) a group of formula (III)

10



wherein  $\text{R}^{16}$  is an alkoxy group containing from 4 to 20 carbon atoms or a group  $-\text{[OCH}_2\text{CHR}^{14}]_t\text{-OR}^{15}$  as herein defined and  $\text{R}^{17}$  is an alkyl group containing from 4 to 20 carbon atoms, optionally substituted phenyl, an alkoxy group containing from 4 to 20 carbon atoms or a group  $-\text{[OCH}_2\text{CHR}^{14}]_t\text{-OR}^{15}$  as herein defined; and wherein  $t$  is from 0 to ten.

15

The term "alkyl" as used herein, including when used in expressions such as "alkoxy", includes linear or branched chain alkyl groups. Optional substituents which may be present in optionally substituted phenyl include  $\text{C}_{1-4}$  alkyl and halogen.

20

In a first embodiment of the invention, there is provided a herbicidal composition comprising a 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I) as hereinbefore defined, and a phosphate of formula (II), wherein  $\text{R}^{11}$ ,  $\text{R}^{12}$  and  $\text{R}^{13}$  are all independently alkoxy groups.

25

In a second embodiment of the invention, there is provided a herbicidal composition comprising a 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I) as hereinbefore defined, and a phosphonate of formula (II), wherein  $\text{R}^{11}$  and  $\text{R}^{12}$  are both

independently alkoxy groups and  $R^{13}$  is an alkyl, alkenyl or optionally substituted phenyl group.

In a third embodiment of the invention, there is provided a herbicidal composition comprising a 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I) as  
5 hereinbefore defined, and a phosphinate of formula (II), wherein  $R^{11}$  is an alkoxy group and  $R^{12}$  and  $R^{13}$  are both independently an alkyl, alkenyl or optionally substituted phenyl group.

Optional alkoxylation of an ester group is represented by the group  
10  $-[OCH_2CHR^{14}]_t-OR^{15}$  as herein defined. It is preferred that the value of  $t$  is from 0 to 10 and more preferably from 0 to 5. If a range of degrees of alkoxylation is present,  $t$  may represent an average value and is not necessarily an integer. Similarly, mixed alkoxylation may take place such that different values of  $R^{14}$  are present in the group  $-[OCH_2CHR^{14}]_t$ . It is preferred that  $R^{15}$  is an alkyl group containing from 1 to 8 carbon atoms. If  $t$  is 0, the group  $-[OCH_2CHR^{14}]_t-OR^{15}$  becomes alkoxy and when  $t$  is 0  
15 therefore the group  $-OR^{15}$  is suitably alkoxy containing from 4 to 20 carbon atoms.

When the compound of formula (II) is a phosphate it is preferred that each of the groups  $R^{11}$ ,  $R^{12}$  and  $R^{13}$  are alkoxy groups containing from 4 to 10 carbon atoms. It is especially preferred that each of  $R^{11}$ ,  $R^{12}$  and  $R^{13}$  contain from 4 to 8 carbon atoms. Preferred phosphates are tri(2-ethylhexyl)phosphate and tributyl phosphate.

20 When the compound of formula (II) is a phosphonate, it is preferred that each of the groups  $R^{11}$  and  $R^{12}$  are alkoxy groups containing from 4 to 10 carbon atoms and  $R^{13}$  is an alkyl group containing from 4 to 10 carbon atoms. Suitable phosphonates are disclosed in WO 98/00021 and the present invention also includes equivalents wherein the relevant alkyl chain length is lower than that disclosed in WO 98/00021. It is  
25 especially preferred that each of  $R^{11}$ ,  $R^{12}$  and  $R^{13}$  contain from 4 to 8 carbon atoms. Preferred phosphonates are bis-(2-ethylhexyl)-2-ethylhexylphosphonate, bis-(2-ethylhexyl-octylphosphonate and bis-butyl-butylphosphonate, particularly bis-(2-ethylhexyl)-2-ethylhexylphosphonate.

When the compound of formula (II) is a phosphinate, it is preferred that  $R^{11}$  is an  
30 alkoxy group containing from 4 to 10 carbon atoms and  $R^{12}$  and  $R^{13}$  are both alkyl groups containing from 4 to 10 carbon atoms. It is especially preferred that each of  $R^{11}$ ,  $R^{12}$  and  $R^{13}$  contain from 4 to 8 carbon atoms. Suitable phosphinates are disclosed in WO

98/00021 and the present invention also includes equivalents wherein the relevant alkyl chain length is lower than that disclosed in WO 98/00021.

Suitably, the concentration of phosphate, phosphonate or phosphinate in the spray tank composition is in the range 0.01% to 0.49 %, suitably in the range 0.025% to 0.49%, more suitably in the range 0.05% to 0.48%, and most preferably in the range 0.05% to 0.2%.

In the context of the present invention, the term "herbicidal composition" is intended to refer to pre-mix concentrate compositions and to the diluted tank-mix compositions.

Herbicidal compositions of the present invention may be formulated as a pre-mix concentrate which is diluted with, dissolved in or dispersed in water shortly before use. In the present invention, the concentrate generally comprises between 30 and 950g/litre of the 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I), preferably 100 to 800g/l, most preferably 150 to 500g/l. The phosphate, phosphonate or phosphinate adjuvant added to the concentrate composition at a weight ratio of the herbicide to the phosphate, phosphonate or phosphinate of from 25:1 and 1:25 and especially 10:1 and 1:10 more especially 1:5 and 5:1. In addition, one or more further active ingredients, for example a second herbicide, may be added to the concentrate composition.

Alternatively, the herbicidal compositions of the present invention are the diluted spray tank composition. The spray tank composition may be obtained by diluting a pre-mix concentrate as described above to the required concentration and adding any other required adjuvants. Alternatively, the spray tank composition may be obtained by diluting a concentrate composition comprising only the 2-(substituted benzoyl)-1,3-cyclohexanedione of formula (I) to the required concentrate, and subsequently adding the required amount of phosphate, phosphonate or phosphinate along with any other required adjuvants. Adjuvants are normally applied as a percentage of the spray volume applied per hectare. Water volume per hectare is normally about 200 litres/ha but can vary from 50 to greater than 3000 for special applications. Adjuvants are nominally applied at volumes of from 0.05% to 1.0% of the spray volume per hectare. Taking 200 l/ha as an average, typical volume rates of adjuvant will therefore be in the region of 100g (0.05%) to 2000g (1.0%). Typical herbicide rates range from 10g/ha to 1kg. Therefore one skilled in the art will expect ratios which cover these typical use rates for both active and

adjuvant. These relate directly to ratio (by weight) of compound of formula (I) to the compound of formula (II) from 50:1 to 1:400. It is preferred that the ratio by weight of the compound of formula (I) to the compound of formula (II) is from 25:1 and 1:25 and especially 10:1 and 1:10 more especially 1:5 and 5:1.

5           When the herbicidal composition of the invention is a pre-mix concentrate, it may thus be formulated as granules, as wettable powders, as suspension concentrates, as emulsifiable concentrates, as granular formulations, powders or dusts, as flowables, as solutions, as suspensions or emulsions. These formulations may contain as little as about 0.5% to as much as about 95% or more by weight of active ingredient. The optimum  
10       amount for any given compound will depend upon formulation, application equipment, and nature of the plants to be controlled.

          Wettable powders are in the form of finely divided particles that disperse readily in water or other liquid carriers. The particles contain the active ingredient retained in a solid matrix. Typical solid matrices include fuller's earth, kaolin clays, silicas and other  
15       readily wet organic or inorganic solids. Wettable powders normally contain about 5% to about 95% of the active ingredient plus a small amount of wetting, dispersing, or emulsifying agent. If liquid compounds of Formula II are formulated as dry products such as WP (or WG), there will be a requirement to absorb/adsorb these into/onto suitable carriers for this formulation type.

20           Suspension concentrates are high concentration suspensions of solid herbicide in a liquid carrier such as water or an oil.

          Emulsifiable concentrates are homogeneous liquid compositions dispersible in water or other liquid, and may consist entirely of the active compound with a liquid or solid emulsifying agent, or may also contain a liquid carrier, such as xylene, heavy  
25       aromatic naphthas, isophorone and other non-volatile organic solvents. In use, these concentrates are dispersed in water or other liquid and normally applied as a spray to the area to be treated. The amount of active ingredient may range from about 0.5% to about 95% of the concentrate.

          Granular formulations include both extrudates and relatively coarse particles, and  
30       are usually applied without dilution to the area in which suppression of vegetation is desired. Typical carriers for granular formulations include sand, fuller's earth, attapulgite

clay, bentonite clays, montmorillonite clay, vermiculite, perlite and other organic or inorganic materials which absorb or which can be coated with the active compound. Granular formulations normally contain about 5% to about 25% active ingredients which may include surface-active agents such as heavy aromatic naphthas, kerosene and other petroleum fractions, or vegetable oils; and/or stickers such as dextrans, glue or synthetic resins. Water emulsifiable granules can also be produced by appropriate means which are well known to those skilled in the art.

Dusts are free-flowing admixtures of the active ingredient with finely divided solids such as talc, clays, flours and other organic and inorganic solids that act as dispersants and carriers.

Formulations which are amenable to the production of mixed products are especially important since a compound of formula II will generally be an oil (or soluble in an organic solvent) and the 2-(substituted benzoyl)-1,3-cyclohexanedione derivatives of formula (I) will generally be highly insoluble in water and therefore most easily formulated as a dispersion in water (or an oil). Thus dispersions of multiple phases are the likely formulations of choice.

Other useful formulations for herbicidal applications include simple solutions of the active ingredient in a solvent in which it is completely soluble at the desired concentration, such as acetone, alkylated naphthalenes, xylene and other organic solvents. Pressurized sprayers, wherein the active ingredient is dispersed in finely divided form as a result of vaporization of a low boiling dispersant solvent carrier, may also be used.

Many of these formulations include wetting, dispersing or emulsifying agents. Examples are alkyl and alkylaryl sulphonates and sulphates and their salts; polyhydric alcohols; polyethoxylated alcohols; esters and fatty amines. These agents, when used, normally comprise from 0.1% to 15% by weight of the formulation.

Another suitable additive is crop oil concentrate (COC) which is well known for herbicides and is a mixture of petroleum oils and non-ionic surfactants, available as, for example AGRI-DEX, PENETRATOR, and PENETRATOR PLUS and from Helena Chemical Company, HER-BIMAX from UAP, ES CROP OIL PLUS from Gromark, and CROP OIL PLUS, from Wilfarm, (83% paraffinic oil, 17% emulsifier surfactant).

Other possible additives include urea ammonium nitrate, a fertiliser, methylated seed oil and ammonium sulphate.

Each of the above formulations can be prepared as a package containing the herbicide together with other ingredients of the formulation (other active ingredients, diluents, emulsifiers, surfactants, etc.). The formulations can also be prepared by a tank mix method, in which the ingredients are obtained separately and combined at the grower site.

The compositions of the present invention have been shown to be particularly effective in the control of weeds, particularly when compared to corresponding compound of formula (I) in the absence of phosphate, phosphonate or phosphinate. Accordingly, a further aspect of the invention provides a process for the control of weeds, said process comprising applying a herbicidally effective amount of a composition according to the invention to the locus of the weeds.

The composition of the invention may be used against a large number of agronomically important weeds, including *Stellaria*, *Nasturtium*, *Agrostis*, *Digitaria*, *Avena*, *Setaria*, *Sinapis*, *Lolium*, *Solanum*, *Phaseolus*, *Echinochloa*, *Scirpus*, *Monochoria*, *Sagittaria*, *Bromus*, *Alopecurus*, *Sorghum halepense*, *Rottboellia*, *Cyperus*, *Abutilon*, *Sida*, *Xanthium*, *Amaranthus*, *Chenopodium*, *Ipomoea*, *Chrysanthemum*, *Galium*, *Viola*, and *Veronica*. For purposes of the present invention, the term "weeds" includes undesirable crop species such as volunteer crops.

Controlling means killing, damaging, or inhibiting the growth of the weeds.

The "locus" is intended to include soil, seeds, and seedlings, as well as established vegetation.

The benefits of the present invention are seen most when the composition is applied to kill weeds in a growing crop, such as Maize (corn). The benefit of the invention is seen most with post-emergent application, but pre-emergent application is also possible.

The present invention is illustrated by the following Example in which all parts and percentages are by weight unless otherwise stated.

**EXAMPLE 1**

The activity of a number of compositions of the present invention was assessed. The weeds were *Echinochloa crus-galli* (ECHCG), *Amaranthus tamariscinus* (AMARE), *Ipomoea hederacea* (IPOHE), *polygonum convolvulus* (POLCO), *Xanthium strumarium*,  
5 (XANST), ?????? (DIGSA), ?????? (VIOAR) and ?????? (BRAPL). The results are given in Table 1. Products were sprayed at a range of g/ha (see table) in 200l/ha water volume and assessed after 21 days for bioefficacy. The activity is expressed as the percentage of weeds controlled.

Table 1: Comparison of activity of mesotrione acid with standard adjuvants vs. activity of mesotrione acid with a compound of formula (II)

| Treatment  | Rate<br>Mesotrione<br>g/ha | ECHG | XANST | AMARE | IPOHE | POLCO | VIOAR | BRAPL | DIGSA |
|--|----------------------------|------|-------|-------|-------|-------|-------|-------|-------|
| Mesotrione Acid +<br>0.5% MSO  | 10                         |      | 84    | 53    | 58    | 55    |       |       |       |
|  | 20                         | 13   | 92    | 58    | 78    | 67    |       |       |       |
|  | 40                         | 70   | 92    | 88    | 83    | 84    |       |       |       |
|  | 80                         | 75   | 96    | 90    | 77    | 95    |       |       |       |
|  | 160                        | 97   | 98    | 89    | 80    | 96    |       |       |       |
|  | 320                        | 99   |       |       |       |       |       |       |       |
| Mesotrione Acid + 1%<br>COC  | 10                         | 73   |       |       | 63    | 20    | 53    | 10    | 95    |
|  | 20                         | 80   |       |       | 80    | 50    | 73    | 17.5  | 97    |
|  | 40                         | 91   |       |       | 78    | 50    | 91    | 60    | 100   |
|  | 80                         | 90   |       |       | 92    | 90    | 96    | 93.5  | 100   |
|  | 160                        |      |       |       |       |       |       |       | 100   |
|  | 320                        |      |       |       |       |       |       |       |       |
| Mesotrione Acid + 1%<br>COC + 2.5% UAN                                   | 10                         |      | 88    |       | 35    | 55    | 35    | 50    | 75    |
|  | 20                         | 47   | 88    |       | 55    | 58    | 73    | 70    | 88    |
|  | 40                         | 80   | 94    |       | 70    | 88    | 90    | 85.5  | 100   |
|  | 80                         | 98   | 96    |       | 80    | 97    | 96    | 95    | 100   |
|  | 160                        | 100  | 97    |       | 78    | 98    |       |       | 100   |
|  | 320                        | 100  |       |       |       |       |       |       | 100   |
| Mesotrione Acid +<br>0.5% tributyl phosphate                             | 10                         |      | 96    | 84    | 70    | 82    |       |       |       |
|  | 20                         | 45   | 96    | 88    | 84    | 70    |       |       |       |
|  | 40                         | 55   | 96    | 90    | 80    | 88    |       |       |       |
|  | 80                         | 88   | 99    | 97    | 78    | 99    |       |       |       |
|  | 160                        | 95   | 98    | 95    | 87    | 99    |       |       |       |
|  | 320                        | 99   |       |       |       |       |       |       |       |
| Mesotrione acid + 0.5%<br>bis(2-ethylhexyl)-2-<br>ethylhexyl phosphonate | 10                         |      | 98    |       | 68    | 80    |       |       | 100   |
|  | 20                         | 93   | 96    |       | 75    | 97    |       |       | 100   |
|  | 40                         | 100  | 98    |       | 83    | 97    |       |       | 100   |
|  | 80                         | 100  | 99    |       | 85    | 98    |       |       | 100   |

|  | 160 | 100 | 99 |  | 94 | 98 |    |      | 100 |
|--|-----|-----|----|--|----|----|----|------|-----|
|  | 320 | 100 |    |  |    |    |    |      | 100 |
| Mesotrione acid +<br>0.075% bis(2-ethylhexyl)<br>phosphonate | 10  | 88  |    |  | 63 | 65 | 33 | 28   | 98  |
|  | 20  | 79  |    |  | 75 | 73 | 73 | 40   | 100 |
|  | 40  | 93  |    |  | 89 | 78 | 85 | 78   | 100 |
|  | 60  | 94  |    |  | 93 | 77 | 97 | 88   | 100 |
|  | 80  |     |    |  |    |    |    |      | 100 |
|  | 160 |     |    |  |    |    |    |      |     |
|  | 320 |     |    |  |    |    |    |      |     |
| Mesotrione Acid +<br>0.2% bis(2-ethylhexyl)<br>phosphonate   | 10  | 83  |    |  | 80 | 63 | 53 | 57.5 | 100 |
|  | 20  | 96  |    |  | 78 | 90 | 99 | 75   | 100 |
|  | 40  | 95  |    |  | 90 | 88 | 95 | 98.5 | 100 |
|  | 80  | 95  |    |  | 90 | 89 | 95 | 94.5 | 100 |
|  | 160 |     |    |  |    |    |    |      | 100 |
|  | 320 |     |    |  |    |    |    |      |     |
| Mesotrione Acid +<br>0.075% tri(2-ethylhexyl) phosphate      | 10  | 80  |    |  | 55 | 33 | 50 | 48   | 96  |
|  | 20  | 95  |    |  | 83 | 75 | 87 | 73   | 100 |
|  | 40  | 94  |    |  | 80 | 87 | 85 | 83   | 100 |
|  | 80  | 95  |    |  | 90 | 94 |    | 100  | 100 |
|  | 160 |     |    |  |    |    |    |      | 100 |
|  | 320 |     |    |  |    |    |    |      |     |
| Mesotrione Acid +<br>0.2% tri(2-ethylhexyl)<br>phosphate     | 10  | 91  |    |  | 65 | 55 | 68 | 48   | 100 |
|  | 20  | 95  |    |  | 73 | 80 | 78 | 73   | 100 |
|  | 40  | 96  |    |  | 90 | 97 | 93 | 83   | 100 |
|  | 80  | 97  |    |  | 92 | 94 | 95 | 100  | 100 |
|  | 160 |     |    |  |    |    |    |      | 100 |
|  | 320 |     |    |  |    |    |    |      |     |